Possible Association between Parental Socioeconomic Status and Development of Autistic Traits among Children Screened 36 Months after Birth in the Norwegian Mother and Child Cohort Study

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ABSTRACT

Objectives: The purpose of our investigation is to explore whether there is an association between parental socioeconomic status and the development of autistic traits among children screened 36 months after birth.

Materials and Methods: Our data were obtained through the Norwegian Mother and Child Cohort Study, a large population-based cohort study. 27 422 children have thus far been screened for the presence of autistic traits using SCQ, a parental self-report form validated for use in clinical samples. After the screening process, which also includes other criteria besides SCQ score, the screen positive children were evaluated clinically and given a diagnosis if DSM-IV criteria were met. These diagnoses were categorized into two of our outcome variables, Autism Spectrum Disorders (ASDs), and ASDs including sub-threshold diagnoses (ASD-ST). Our third outcome variable was the SCQ-score using a specific cutoff. The exposure variables were parental education, income, age and marital status.

Results: Statistically significant correlations were found between high SCQ-score and low parental education level and income, this being most pronounced in the case of maternal education. Less clear results were found for ASD and ASD-ST, possibly due to small numbers.

Conclusions: It seems that low parental socioeconomic status is associated with an increased prevalence of autistic traits among children screened 36 months after birth.

INTRODUCTION

Autism spectrum disorders (ASDs) are a group of developmental disorders characterized by abnormalities in communicative skills, social interaction, and by a restricted, stereotyped and repetitive behaviour. The term autism was first used by Leo Kanner (Kanner, 1943) in a report describing 11 children with strong behavioural similarities, although the term was used 5 years prior to this by Hans Asperger, who was investigating a milder form, later to be known as Asperger syndrome. Today, included as ASDs, according to *Diagnostic and Statistical Manual of mental disorders, fourth edition (DSM-IV),* are 1) Autistic disorder, 2) Asperger syndrome and 3) Pervasive developmental disorders- not otherwise specified (PDD-NOS). The best known and researched among these is autistic disorder (infantile autism), henceforth called autism. Asperger syndrome and PDD-NOS can be thought of as less extreme variations on the same theme (Goodman & Scott, 2005), giving rise to the idea of an “autistic spectrum” ranging from autism at one extreme to normal children at the other.

Most studies of a newer date report that the best estimate for ASD prevalence in Europe and North America is 6/1000 (Johnson et al., 2007). Of these, between 25 and 60% are accounted for by classical autism (Goodman & Scott, 2005). This is consistent with the prevalence of 2,2/1000 found in a large Canadian study (Fombonne et al., 2006).

ASDs are biologically based neurodevelopmental disorders that are highly heritable. In a minority of cases (<10%), ASDs may be associated with a medical condition or a known syndrome, such as Fragile X syndrome, Rett syndrome or tuberous sclerosis. Environmental factors may also play a role. It has been suggested that environmental exposures may act as central nervous system teratogens in early gestational life (Arndt et al., 2005). It is also an open question whether nutritional factors are of etiological importance. Advanced paternal age (Reichenberg et al., 2006; Croen et al., 2007) and advanced maternal age (Croen et al., 2007; Kolevzon et al., 2007) have been shown to be associated with an increased risk of having children with an ASD. This could be due to an increased risk of germline mutations when age increases (Reichenberg et al., 2006).

Previous studies on the possible link between socioeconomic status and autism

Whether the prevalence of ASDs in some way is related to parental socioeconomic status (SES) factors, such as education, occupational group, income, parental age and race, has been a subject of discussion for more than half a century. This possible link was first described by Leo Kanner in the 1940's, who noticed that among the 11 children originally described, every single one came from a high social status family. For the decades to follow, numerous reports and studies were published; most of them describing children with autistic traits as coming from families with high SES, while a minority did not demonstrate this connection.

Schopler reviewed these studies (Schopler, 1979), and revealed that the studies with findings on either side of the social class issue did not use identical criteria for diagnosing children or for defining social class. He identified 7 possible factors that could form the basis of a selection bias towards families with high SES. These included the fact that availability of diagnostic services is greater among high SES families, and that obtaining a detailed child history from low SES parents could be more difficult than would be the case with high SES parents, because low SES families would more likely lack the aid of diaries, photo albums and home videos. In fact, several of the studies performed prior to 1979 had used incomplete data history as an exclusion criterion.

One year later, in an epidemiological study performed in South East London, Wing (Wing, 1980) concluded that her findings supported the view that reports of a social class bias in autism may be explained by factors affecting referral and diagnosis.

Further investigation of the studies Schopler reviewed was performed by Sanua (Sanua, 1986). He opined that Schopler's conclusions could be wrong, due to what he referred to as a bimodal distribution, i.e. that the group of children with classical autism could accumulate in the higher SES groups, while children with other disorders, such as mental retardation and language disorders, would be more common in the lower SES groups. Thus, what would initially look like a study showing no association between autistic traits and high SES, could in reality be two different diagnostic entities, accumulating on opposing sides of the SES scale. He therefore concluded that the issue regarding the SES-autism link still remained unresolved.

In a Swedish population-based study (Steffenburg & Gillberg, 1986) no obvious or significant social class bias among the autistic and autistic-like children was found. If anything, there was a slight trend towards more autism in the lower social classes.

During the 1990's, most investigators (Gillberg, Steffenburg & Schaumann, 1991; Fombonne & du Mazaubrun, 1992; Arvidsson et al., 1997) did not observe any significant association between autism and SES.

In a large Danish case-control study, nested within a cohort of all children born in Denmark between 1972 and 1999 (Larsson et al., 2005), totalling 698 children with a diagnosis of autism, the adjusted analyses were unable to demonstrate a significant association between autism and SES. An American study conducted a few years later (Bhasin et al., 2007) discovered a relation between both high maternal age and educational level, and the risk of having an autistic child. They however argued that ascertainment bias could be a likely explanation for this, pointing out that the American health care system is not as readily available for the low SES classes compared to Denmark, where health care is equally available for all and is free of charge.

Aims of the study

The purpose of our investigation is to explore whether there is an association between parental socioeconomic status and the development of autistic traits among children screened 36 months after birth within the Norwegian Mother and Child Cohort Study (*Den norske mor og barn-undersøkelsen, MoBa*), a large population-based cohort study intending to identify causes of rare and serious diseases.

We also wanted to analyse our material with regard to possible SES skewness, comparing compliance- and non-compliance groups, looking at response to the questionnaires among all participants, and attendance at further diagnosing among children who are screen-positive for autistic traits.

MATERIALS AND METHODS

Our study is based on data obtained in the Autism Birth Cohort (ABC) study, a case-control study nested within the Norwegian Mother and Child Cohort Study (*Den norske mor og barn-undersøkelsen, MoBa*).

MoBa and the ABC study

MoBa is a nationwide cohort study with the now fulfilled aim of including 107.000 pregnancies (as of December '08). As the unit used in MoBa is pregnancy, one mother could potentially participate several times. The intention behind MoBa has been to increase our knowledge about how heritable and environmental factors play a role in the etiology of rare and serious diseases. Essential to the study is the fact that records of the exposure variables are obtained prior to disease debut, avoiding the potential problem of recall bias. Participants have been recruited by means of a questionnaire and a consent form distributed to pregnant women approx. 3 weeks prior to the routine ultrasound control in gestational week 17-19. At the same time the father is asked to participate, receiving a consent form and a questionnaire. Further questionnaires are sent to the women in gestational weeks 22 and 30, and 6, 18 and 36 months after birth. They also receive a questionnaire when the child is 6 years old. The father receives no further questionnaires. Also obtained are biological samples from both mother, father and child. Blood samples from the mother are taken at the routine ultrasound check at gestational week 17-19, and immediately after birth. At the ultrasound check, there is also obtained a urine sample from the mother and a blood sample from the father, if participating. Another blood sample is obtained from the umbilical cord immediately after partition.

The specific aims of the ABC study are firstly to establish the Autism Birth Cohort (ABC) through ascertainment of potential ASD cases and selection of controls from the MoBa cohort, secondly to identify environmental factors that may be directly or indirectly associated with ASD, and thirdly to describe the natural history of clinical, anthropometric, and neurobehavioral features of ASD.

Potential cases of ASD and a random sample of controls are invited to participate in the ABC study. Potential ASD cases are identified through screening of MoBa participants for autistic traits at 36 months of age. Professional referral of MoBa-participants and self-referrals are also accepted, if there is a suspicion of ASD. Potential cases will also be identified through hospital registries and the Norwegian Patient Registry.

The screening algorithm and the Social Communication Questionnaire - SCQ

The screening algorithm is based on the Social Communication Questionnaire (SCQ), a form that has been validated for autism screening in clinical samples. These samples have consisted of children referred to specialist services for evaluation. The entire Current form (see later) of the SCQ has been translated to Norwegian, and is to be found in the 36 months questionnaire. The SCQ is a 40-item, parent-report screening measure that taps the symptomatology associated with ASDs (Rutter et al., 2003). The SCQ is divided into 3 sub-domains; reciprocal social interaction domain, communication domain and restricted, repetitive and stereotyped patterns of behaviour domain. All the items are administered in a yes/no response format. The SCQ focuses on behaviours that are rare in unaffected individuals. The first question (Is she/he now able to talk using short phrases or sentences?) determines whether questions 2 through 7 are to be answered, and does not in itself contribute to the total score. The following 6 questions assess the child's verbal skills. The remaining 33 questions relate to non-verbal features. In the scoring of SCQ items, responses indicative of ASD are scored by one point each whereas responses indicative of normal development are given a zero score. This sums up to a maximum total score of 39.

There are 2 forms available for the SCQ, the Current form and the Lifetime form; of these we will only be referring to the Current version. This version is designed for use in children below the age of 5. The SCQ is based on the Autism Diagnostic Interview (ADI), a comprehensive diagnostic tool considered the gold standard in autism diagnostics, however taking a couple of hours to complete. In comparison, the SCQ is an easy-to-use questionnaire, the items being deliberately chosen to match the ADI items that have been found to have discriminative diagnostic validity (Rutter et al., 2003). The first studies evaluating the SCQ showed promising agreement between the SCQ and the Autism Diagnostic Interview – Revised (ADI – R) (Bishop & Norbury, 2002; Howlin & Karpf, 2004). These studies were however conducted on clinical samples, meaning that inferences about use of the SCQ as a general screening tool were not possible (Corsello et al., 2007). As far as we know, MoBa is the first study to use SCQ as a screening tool on a normal population, and in a large sample.

It was recommended in the SCQ manual (Rutter et al., 2003) that 15 be used as a cutoff for differentiating ASDs from non-ASDs. The original standardization data (Berument et al., 1999) showed the mean score for children with autism to be 24,2. However, a significant minority had scores near 15, and it was found that a cutoff greatly above 15 resulted in an unacceptably high proportion of false negatives. As a reference, the general population mean has been shown to be 5,2 (Berument et al., 1999). An evaluation of the SCQ was performed in 2007 (Corsello et al., 2007), discovering lower sensitivity in the younger children and lower specificity for all age groups than reported in the original study. When the cutoff of >=15 was used, the SCQ resulted in lower sensitivity than the ADI-R, which, it was argued, is not ideal for a screening measure with the goal of including as many children who may have an ASD as possible. It was advocated that the less stringent SCQ cutoff >=12 be used. This will increase sensitivity, but of course lower specificity. Given the effects of age, the sensitivity and specificity of the ADI-R and SCQ were compared for different age groups. It was concluded that identifying a single cutoff on the SCQ that worked equally well across age groups was not possible.

In previous studies, the samples have consisted mainly of children aged above 3 years. Our study differs from past experience in 2 ways; both in the sense that our sample consists of young children, and in the sense that we are screening a general population. It was hypothesized when MoBa was initiated that 3-year-olds would be prone to give positive answers to the verbal part of the SCQ, even if they are non-autistic. For instance, it is not unusual for a normal 3-year-old to get his/her pronouns mixed up (item 5 in the SCQ form). Therefore, the first 7 items were excluded from the screening process in our study, yielding a new SCQ-33 total score, measuring the response only to items 8 through 40. Using this new total score of 33, it seemed reasonable to reduce the cutoff (compared to 15, as used in the original study) in a proportionate manner. A cutoff of >=12 was chosen on pragmatic grounds. These cases will in tables be referred to as "SCQ high scores". It is demanded in our study that not more than four of the SCQ-33 items are left unanswered, for a SCQ-33 total score to be considered valid.

The screening algorithm, though based on the SCQ-cutoff >=12, also contains five other criteria. All criteria are listed below:

1. SCQ-33 score >=12.
2. Repetitive behaviour sub-domain score on SCQ-33 = 9 (out of 9).
3. Parent reports language delay (question 3.19 in the 36 months questionnaire) AND child has been referred to a specialist.
4. Parent reports autism/autistic trait (question 3.23 in the 36 months questionnaire) OR reports that the child has been referred to a specialist .
5. Parent reports worry that the child shows very little interest in playing with other children (question 31.4 in the 36 months questionnaire).
6. Parent reports that others (nurse, teacher, family member) have expressed worry about the child's development (question 31.3 in the 36 months questionnaire).

To count as screen positive and thereby included in the ABC, the child must either 1) Meet any of criteria 1, 2, 3 or 5, AND at the same time criterion 6; or 2) Meet criterion 4.

Diagnostic evaluation

Following the screening, ASD caseness is confirmed through an extensive in-person clinical evaluation at Nic Waal's Institute in Oslo. The assessment includes validated diagnostic tools (Autism Diagnostic Interview – Revised [ADI-R], Autism Diagnostic Observation Schedule), psychometric testing (Stanford-Binet Intelligence Scales 5th edition, Mullen Scales of Early Learning), other standardized parent interviews (Preschool Age Psychiatric Assessment, Vineland Adaptive Behavior Scales), a physical examination and a final diagnostic interview. Blood samples are collected from all children (plasma, full blood, DNA, RNA), and from parents, if they have not previously provided blood samples to MoBa.

After this thorough evaluation, the children are either assigned to one out of 13 possible diagnostic categories, or assessed as having no diagnosis/sub-threshold diagnosis. The diagnostic categories are:

1. Autistic disorder.
2. Profound disability with autism.
3. PDD-NOS.
4. Asperger syndrome.
5. Childhood disintegrative disorder.
6. Mental retardation.
7. Language disorder.
8. Other psychiatric or neurodevelopmental disorder.
9. Sub-threshold Autistic disorder.
10. Sub-threshold PDD-NOS.
11. Sub-threshold Asperger.
12. Sub-threshold language disorder.
13. Sub-threshold other psychiatric or neurodevelopmental disorder.

Defined as ASDs in our study are categories 1 through 5. Categories 9, 10 and 11 constitute sub-threshold ASDs, which are defined in the ABC study as diagnoses assigned to children having distinct autistic features, but not sufficient to meet the DSM-IV criteria for any ASD. Combining the ASD and the sub-threshold ASD, we obtain a new entity, hereafter referred to as ASD-ST. Thereby our 2 groups used for further analyses are:

ASD: Categories 1-5.

ASD-ST: Categories 1-5 AND 9-11.

The screening and selection of controls have been carried out for MoBa participants born after June 30th 2002. Children born prior to that date have not gone through the regular case identification procedure, but referrals of such children are accepted.

Exposure and outcome variables

Normally thought of as the most important measures of socioeconomic status are educational level, occupation and income. Of these we have selected educational level and income as our exposure variables, and chosen not to look at occupation. This is due to the answer categories to the occupational question not being specific for SES groups, inasmuch as a person working in either public or private sector might very well belong to any SES group. We also reasoned that occupation would provide little information about SES level that could not be obtained from income or educational level. Concerning the education variable, we have chosen to look at the highest completed education, and not taken into account whether other education is in progress. We reasoned that education in progress would not be a good predictor of how high the person's education would be in the end, and also considered it more reliable to look at a measure that has already been achieved.

Our outcome variables are SCQ-33 using the cutoff of >=12, ASD-ST and ASD (as defined above). Adjustment factors used in our analyses are maternal and paternal age and mother's marital status. Information about the parents' age has been obtained from the Medical Birth Registry of Norway (MBRN). In the adjusted analyses, we divided the maternal age into 2 groups; one under the age of 35, and one consisting of 35 and above. We divided the father's age in a similar way, this time using 40 years as cutoff. These cutoffs were chosen to meet two conditions; they should be high, but at the same time allow a substantial number of children with high SCQ scores in all categories. Marital status has, where not otherwise specified, been obtained from the 36 months questionnaire. For marital status we recoded the answers into 2 new categories; one consisting of married and cohabitants, and the other consisting of single, divorced, widows and those responding “other”. The latter category is labelled “mother not living with father” in the logistic regression analysis tables.

In addition to being used as adjustment factors in the logistic regression analyses concerning educational level and income, we also present independent cross tables where maternal age, paternal age and maternal marital status are paired with SCQ high score and ASD-ST.

The categories for the 2 exposure variables are as follows (**Tables A and B**):

Table A. Completed education.

Category	Educational level
1	9-year secondary school
2	1-2 year high school
3	Vocational high school
4	3-year high school general studies, junior college
5	Regional technical college, 4-year university degree
6	University, technical college, more than 4 years

Table B. Income.

Category	Income
1	No income
2	Below 150 000
3	150 000-199 999
4	200 000-299 999
5	300 000-399 999
6	400 000-499 999
7	Above 500 000

For father’s income, there is also a category “unknown”.

Statistical analyses

Data are presented using standard cross tabulations, and analysed using logistic regression with SPSS 14.0. Missing cases are included in all cross tabulations, so that total numbers are the same in all tables.

In logistic regression models, the probability of the occurrence of a given event is modelled as a function of the exposure variables and the covariates. The model takes on the following form: $\log [p/1-p] = \alpha + \beta 1 {*} X1 + \ldots + \beta n Xn$. $\log [p/1-p]$ = log odds of the event, and p = probability of the event. X1-Xn represent the exposure variables and covariates, whereas β1-βn are the corresponding regression coefficients. α is a constant. The regression coefficients and the constant are estimated by the computer using so-called “maximum likelihood” techniques.

The odds ratio for an increase by one unit of a given X is equal to eβ, where β is the regression coefficient corresponding to X. The odds ratio is an estimate of how p is affected by changes in X, provided that all other variables are kept constant.

The logistic regression tables output most relevant to our purpose, is the Exp(B) values with their respective 95% C.I. These should be interpreted as adjusted odds ratios (AOR), where the group in question (for instance 3-year high school) is compared to a given reference group. For education the reference is the highest group (college/university), and for income it is the group with the most participants, looking at mothers and fathers combined (200 000-299 999). As for the age and marital status groups, the smallest groups (mother's age >=35, father's age >=40; and the single/divorced group) are compared with the larger reference groups, consisting of the remainder. That the ORs are adjusted (AOR), means that the 2 exposure variables are adjusted by the 3 "adjustment factors" (mother's and father's age and mother's marital status). The adjustments are two-way, so that the adjustment factors are also adjusted in the same way by each other and the unadjusted exposure variables.

Possible selection bias in our study

To assess whether selection bias among participants could influence our results, we wanted to address 3 questions:

- Are there any differences in socioeconomic status among those responding to the 36 months questionnaire, compared to those not responding?
- Among those screening positive in the ABC study, are there any socioeconomic status differences between those who meet for clinical evaluation, and those who do not?
- Are there any differences in the mean SCQ-33 score between those meeting for clinical evaluation and those not meeting, in the following sub-groups:
    - The screen positive children.
    - The children who are screen positive AND have SCQ-33 >=12.

All children born after December 31st 2004 are excluded from these analyses. Thereby all participants have had enough time to answer the 36 months questionnaire and be clinically evaluated. Regarding the first question, children born prior to February 1st 2002 are also excluded, as the 36 months questionnaire was not regularly distributed to participants with children born before that date. The analyses regarding selection bias are not performed sex-specific, with the exception of the question regarding mean SCQ-33 scores, as these are significantly different for boys and girls.

The results of these analyses will be presented using cross tabulations and, for the mean SCQ-33 scores, independent sample t-tests.

RESULTS

At the time of writing, our database includes 56 033 pregnancies. Information about the child's sex is available for 55 817 of these; we have excluded the rest from further analyses as most of these are stillborn. To this date, 27 422 (13 916 boys and 13 506 girls) have returned the 36 months questionnaire. The remainder has either failed to return the questionnaire, or have not yet received it due to the child's age. From the responses, 26 886 valid SCQ-33 scores were obtained, and 316 (223 boys and 93 girls – boy/girl-ratio: 2,40) were >=12. The total number of screen positives using the aforementioned criteria is 337 (231 boys and 106 girls – boy/girl-ratio: 2,18). The overlap between these groups (316 vs. 337) consists only of 103 cases, showing that screening criteria other than the SCQ-33 >=12-criterion contributed a larger number of participants to the ABC study. **Table 1** shows how the different screening criteria contribute cases to the screen-positive-population. Notice that one child may belong to several of the categories, resulting in a sum (1+6, 2+6, 3+6, 5+6, 4 alone) that exceeds the number of screen positives (337).

Table 1. Number of children being positive for each screening criterion.

Criterion	Number of children
1	316
2	161
3	333
4	30
5	262
6	1299
1 and 6	100
2 and 6	14
3 and 6	219
4 and 6	25
5 and 6	98

Of the 337 screen positives, 136 have, at the time our database was composed, attended the clinical evaluation. Among these there were 99 boys and 37 girls, yielding a boy/girl-ratio of 2,68. Be aware though that the attendance percentage yielded by the aforementioned numbers (136/337 = 40,4%) is falsely low, as a significant proportion of the 337 screen positives have not yet had the time to attend the clinical examination. This is illustrated if we leave children born in 2005 or later out of the equation, as we will do in later analyses where we consider it relevant. Then the number of screen positives is 275 (190 boys and 85 girls) and the number of attendants to clinical examination is 132 (96 boys and 36 girls), this time yielding an attendance rate of 48,0%.

Of the 41 ASD cases diagnosed thus far, there are 29 boys and 12 girls. Of the 61 ASD-ST cases, there are 45 boys and 16 girls. As there is a marked preponderance, with boys dominating with respect both to the SCQ-cutoff and to the final ASD diagnoses, we have chosen to perform sex-specific analyses and tables.

Even if it is not strictly relevant to the purpose of our investigation, we believe it is interesting to investigate how the SCQ-33 score performs as a predictor of a clinical diagnosis among the screen positive children. As SCQ is designed to screen for the presence of ASD, and not the sub-threshold diagnostic criteria used in MoBa, we will only look at cases of ASD in this section. In the population of screen positives with valid SCQ-33 scores, there have so far been diagnosed 31 cases of ASD. This means that the remaining 10 ASD cases have either been referred to the clinical evaluation without taking part in the screening process, or have failed to answer a sufficient number of SCQ items. Out of these 31 cases, 21 had SCQ-33 scores >=12, yielding a percentage of 67,7%. This should be compared to the corresponding numbers for the entire screen-positive population using the same criteria; 103 SCQ-33 scores of >=12 among the 325 screen positive children with valid SCQ-33 scores, yielding a percentage of 31,7%. This means that SCQ has a strong predictive value compared to the other screening criteria combined.

Our results will be divided into 4 parts: First we look at how SCQ-33 >=12 as an outcome variable depends on socioeconomic status factors. Then we look at how ASD-ST and ASD as outcome variables depend on SES factors, and finally we investigate how possible selection bias could influence our results.

<u>SCQ-33 >=12 as outcome variable</u>

We will start by looking at how the SCQ-33 >=12 cutoff depends on maternal education by presenting cross tabulations and logistic regression tables, see **Table 2**. When comparing observed and expected counts, there is a marked difference between higher educational groups (university/college) and all other groups. In the latter groups there is an increased risk of obtaining a high SCQ-score, this being especially pronounced in the 9-year secondary school group, scoring 5,9% and 2,9% for boys and girls respectively. This trend is seen in both sex categories. The percentages show a falling trend with longer education.

Table 2. SCQ high score by maternal education.

Mother's educational level	Boys SCQ-33 >=12	Boys Total	Boys %>=12	Girls SCQ-33 >=12	Girls Total	Girls %>=12
9-year secondary school	18 (4,9)	307	5,9	8 (1,9)	279	2,9
1-2 year high school	13 (10,0)	624	2,1	10 (4,4)	634	1,6
Vocational high school	35 (28,4)	1772	2,0	21 (11,6)	1681	1,2
3-year high school	40 (33,0)	2059	1,9	19 (13,6)	1980	1,0
3-4-year university/college	79 (90,1)	5622	1,4	18 (37,4)	5439	0,3
University/college >4 years	28 (38,8)	2442	1,1	7 (17,2)	2503	0,3
Missing	10 (17,5)	1090	0,9	10 (6,8)	990	1,0
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the educational level groups.
The %>=12 is the share of children with SCQ-33>=12 within each educational group.
"Missing" represents subjects who either did not provide an answer to the educational question, or did not obtain valid SCQ-33-scores.

The adjusted logistic regression analyses (**Tables 3a and 3b**) show an AOR between 9-year secondary school and university/college >=4 years (reference) of 4,66 for boys and 9,70 for girls, both being statistically significant. Other groups being significantly different from the reference group are vocational high school for boys (AOR=1,66); and 1-2 year high school (AOR=5,43), vocational high school (AOR=4,25) and 3-year high school (AOR=3,14) for girls. Notice that among fathers aged 40 and above, there is an increased risk of SCQ-33 >=12 compared to the younger group of fathers. This is significant in the boys' section (AOR=1,64). On the other hand, mothers aged 35 and above seem to have a decreased risk of SCQ-33 >=12 compared to the younger mothers. This trend is however not statistically significant for neither boys nor girls. Single and divorced mothers have an increased risk of SCQ-33 >=12, this being significant in the boys' group (AOR=1,88).

Table 3a (boys). Odds ratios for SCQ high score by maternal education.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
9-year secondary school	1,54	0,31	24,17	0,000	4,66	2,52-8,60
1-2 year high school	0,55	0,34	2,59	0,108	1,73	0,89-3,27
Vocational high school	0,51	0,26	3,91	0,048	1,66	1,00-2,75
3-year high school	0,49	0,25	3,79	0,052	1,63	0,99-2,65
3-4-year university/college	0,19	0,22	0,75	0,388	1,21	0,78-1,87
University/college >4 years	-	-	-	-	1,00	-
Mother >= 35 years	-0,39	0,22	3,19	0,074	0,68	0,44-1,04
Father >= 40 years	0,50	0,22	5,05	0,025	1,64	1,07-2,53
Mother not living with father	0,63	0,23	7,57	0,006	1,88	1,20-2,95

University/college >4 years used as reference.
Odds ratios are approximately equal to relative risks.

Table 3b (girls). Odds ratios for SCQ high score by maternal education.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
9-year secondary school	2,27	0,53	18,71	0,000	9,70	3,47-27,17
1-2 year high school	1,69	0,50	11,61	0,001	5,43	2,05-14,37
Vocational high school	1,45	0,44	10,85	0,001	4,25	1,80-10,06
3-year high school	1,20	0,44	7,27	0,007	3,14	1,39-7,92
3-4-year university/college	0,15	0,45	0,12	0,735	1,16	0,49-2,79
University/college >4 years	-	-	-	-	1,00	-
Mother >= 35 years	-0,67	0,38	3,02	0,082	0,51	0,24-1,09
Father >= 40 years	0,61	0,35	2,96	0,086	1,83	0,92-3,65
Mother not living with father	0,38	0,36	1,12	0,291	1,46	0,72-2,97

University/college >4 years used as reference.
Odds ratios are approximately equal to relative risks.

In **Table 4** we look at how the father's educational level influences the SCQ-33 score. The trend is basically the same as we saw with the mother's education, although this time less pronounced.

Table 4. SCQ high score by paternal education.

	Boys			Girls		
Father's educational level	SCQ-33 >=12	Total	%>=12	SCQ-33 >=12	Total	%>=12
9-year secondary school	18 (9,7)	605	3,0	9 (4,4)	637	1,4
1-2 year high school	22 (13,2)	821	2,7	7 (5,4)	789	0,9
Vocational high school	63 (56,2)	3507	1,8	33 (23,4)	3400	1,0
3-year high school	21 (24,1)	1506	1,4	9 (10,1)	1470	0,6
3-4-year university/college	49 (54,5)	3400	1,4	12 (22,5)	3271	0,4
University/college >4 years	30 (39,0)	2433	1,2	10 (16,5)	2403	0,4
Missing	20 (26,3)	1644	1,2	13 (10,6)	1536	0,8
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the educational level groups.
The %>=12 is the share of children with SCQ-33>=12 within each educational group.
"Missing" represents subjects who either did not provide an answer to the educational question, or did not obtain valid SCQ-33-scores.

Adjusted logistic regression analyses regarding the father's education (**Tables 5a and 5b**) have been performed as above. Significant trends are observed for 9-year secondary school among both sexes (boys: AOR=2,13; girls: AOR= 2,90), for 1-2 year high school for boys (AOR=2,02) and for vocational high school in the girls' section (AOR=2,21), the trends showing increased risk of SCQ-33 >=12 in all 4 cases.

Table 5a (boys). Odds ratios for SCQ high score by paternal education.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
9-year secondary school	0,75	0,31	6,09	0,014	2,13	1,17-3,87
1-2 year high school	0,70	0,29	6,05	0,014	2,02	1,54-3,53
Vocational high school	0,33	0,23	2,10	0,147	1,39	0,89-2,15
3-year high school	0,07	0,29	0,05	0,817	1,07	0,61-1,88
3-4-year university/college	0,14	0,23	0,35	0,555	1,15	0,73-1,82
University/college >4 years	-	-	-	-	1,00	-
Mother >= 35 years	-0,33	0,22	2,23	0,136	0,72	0,46-1,11
Father >= 40 years	0,41	0,23	3,05	0,081	1,50	0,95-2,36
Mother not living with father	0,73	0,23	9,73	0,002	2,07	1,31-3,27

University/college >4 years used as reference.
Odds ratios are approximately equal to relative risks.

Table 5b (girls). Odds ratios for SCQ high score by paternal education.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
9-year secondary school	1,07	0,47	5,15	0,023	2,90	1,16-7,29
1-2 year high school	0,66	0,50	1,77	0,184	1,94	0,73-5,14
Vocational high school	0,79	0,36	4,76	0,029	2,21	1,08-4,50
3-year high school	0,33	0,46	0,50	0,478	1,39	0,56-3,44
3-4-year university/college	-0,15	0,43	0,12	0,730	0,86	0,37-2,00
University/college >4 years	-	-	-	-	1,00	-
Mother >= 35 years	-0,60	0,38	2,49	0,115	0,55	0,26-1,16
Father >= 40 years	0,61	0,35	2,99	0,084	1,84	0,92-3,69
Mother not living with father	0,55	0,38	2,06	0,151	1,73	0,82-3,66

University/college >4 years used as reference.
Odds ratios are approximately equal to relative risks.

Then we look at how SCQ-33 scores vary with parental income, starting with maternal (**Table 6**). For girls there are no clear trends, the below 150 000-group being a possible exception with 26 observed vs. 14,5 expected. For boys there is an obvious trend towards more SCQ-33 positives in the 2 lowest income groups (4,5% and 2,3% respectively, compared to the 1,6% mean).

Table 6. SCQ high score by maternal income.

	Boys			**Girls**		
Mother's income	SCQ-33 >=12	Total	%>=12	SCQ-33 >=12	Total	%>=12
No income	13 (4,6)	289	4,5	2 (2,0)	289	0,7
Below 150 000	52 (36,0)	2249	2,3	26 (14,5)	2105	1,2
150 000-199 999	23 (28,2)	1759	1,3	8 (11,1)	1608	0,5
200 000-299 999	81 (85,6)	5340	1,5	40 (35,9)	5215	0,8
300 000-399 999	31 (38,0)	2374	1,3	7 (16,7)	2430	0,3
400 000-499 999	11 (10,5)	652	1,7	2 (4,4)	637	0,3
Above 500 000	4 (5,8)	362	1,1	1 (2,6)	379	0,3
Missing	8 (14,3)	891	0,9	7 (5,8)	843	0,8
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the income groups.
The %>=12 is the share of children with SCQ-33>=12 within each income group.
"Missing" represents subjects who either did not provide an answer to the income question, or did not obtain valid SCQ-33-scores.

Tables 7a and 7b show adjusted logistic regression analyses for boys and girls respectively. The two lowest categories demonstrate significant tendencies towards more boys with SCQ-33 scores >=12 (AOR=2,87; AOR=1,45). For girls no significant tendencies were found.

Table 7a (boys). Odds ratios for SCQ high score by maternal income.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
No income	1,06	0,31	11,89	0,001	2,87	1,58-5,24
Below 150 000	0,37	0,18	4,30	0,038	1,45	1,02-2,07
150 000-199 999	-0,16	0,24	0,46	0,500	0,85	0,53-1,36
200 000-299 999	-	-	-	-	1,00	-
300 000-399 999	-0,15	0,21	0,50	0,479	0,86	0,57-1,31
400 000-499 999	0,14	0,33	0,18	0,673	1,15	0,61-2,17
Above 500 000	-0,27	0,52	0,28	0,599	0,76	0,28-2,10
Mother >= 35 years	-0,36	0,22	2,62	0,105	0,70	0,45-1,08
Father >= 40 years	0,47	0,22	4,49	0,034	1,61	1,04-2,49
Mother not living with father	0,70	0,23	9,43	0,002	2,00	1,29-3,12

200 000-299 999 used as reference.
Odds ratios are approximately equal to relative risks.

Table 7b (girls). Odds ratios for SCQ high score by maternal income.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
No income	-0,17	0,73	0,06	0,814	0,84	0,20-3,51
Below 150 000	0,46	0,26	3,23	0,072	1,58	0,96-2,60
150 000-199 999	-0,45	0,39	1,32	0,251	0,64	0,30-1,37
200 000-299 999	-	-	-	-	1,00	-
300 000-399 999	-0,97	0,41	5,58	0,018	0,38	0,17-0,85
400 000-499 999	-0,88	0,73	1,47	0,226	0,41	0,10-1,73
Above 500 000	-1,05	1,02	1,07	0,301	0,35	0,05-2,56
Mother >= 35 years	-0,32	0,36	0,81	0,367	0,73	0,36-1,46
Father >= 40 years	0,54	0,35	2,34	0,126	1,72	0,86-3,43
Mother not living with father	0,32	0,40	0,66	0,418	1,38	0,63-3,02

200 000-299 999 used as reference
Odds ratios are approximately equal to relative risks.

Looking at the father's income (**Table 8**), we see a similar trend towards a higher proportion of boys with SCQ-33 >=12 in the lower income groups than in the rest. The percentages for the 3 lower groups are 4,4, 2,9 and 3,2. This should be compared to the average of 1,6. In the girls section, it is difficult to draw any conclusions. Interesting however, are the numbers presented in the unknown categories, where the mother is not familiar with the father's income. These are higher than the expected counts, though not by much as the categories are small.

Table 8. SCQ high score by paternal income.

Father's income	Boys SCQ-33 >=12	Boys Total	Boys %>=12	Girls SCQ-33 >=12	Girls Total	Girls %>=12
No income	5 (1,8)	113	4,4	0 (0,7)	108	0,0
Below 150 000	21 (11,7)	730	2,9	10 (4,8)	700	1,4
150 000-199 999	19 (9,6)	601	3,2	2 (4,0)	578	0,3
200 000-299 999	61 (59,3)	3701	1,6	21 (24,6)	3576	0,6
300 000-399 999	51 (65,4)	4080	1,3	31 (27,5)	3991	0,8
400 000-499 999	25 (28,8)	1797	1,4	9 (11,9)	1721	0,5
Above 500 000	24 (25,0)	1562	1,5	9 (10,7)	1557	0,6
Unknown	4 (2,4)	151	2,6	4 (0,9)	125	3,2
Missing	13 (18,9)	1181	1,1	7 (7,9)	1150	0,6
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the income groups.
The %>=12 is the share of children with SCQ-33>=12 within each income group.
"Missing" represents subjects who either did not provide an answer to the income question, or did not obtain valid SCQ-33-scores.

The adjusted odds ratios show that in the boys section, both the below 150 000 group (AOR=1,67) and the 150 000-199 999 group (AOR=1,95) have AORs significantly different from the reference group. Among the girls, both the below 150 000-group and the "unknown"-group were significantly different from the reference group, with AORs=2,39 and 5,05.

Table 9a (boys). Odds ratios for SCQ high score by paternal income.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
No income	0,89	0,48	3,47	0,063	2,44	0,95-6,26
Below 150 000	0,51	0,26	3,96	0,047	1,67	1,01-2,77
150 000-199 999	0,67	0,27	6,23	0,013	1,95	1,15-3,28
200 000-299 999	-	-	-	-	1,00	-
300 000-399 999	-0,26	0,19	1,83	0,176	0,77	0,53-1,12
400 000-499 999	-0,15	0,24	0,37	0,545	0,87	0,54-1,38
Above 500 000	-0,03	0,25	0,02	0,900	0,97	0,60-1,57
Unknown	0,32	0,53	0,36	0,550	1,37	0,49-3,86
Mother >= 35 years	-0,48	0,23	4,26	0,039	0,62	0,40-0,98
Father >= 40 years	0,52	0,23	5,13	0,024	1,68	1,07-2,62
Mother not living with father	0,70	0,23	9,32	0,002	2,02	1,29-3,17

200 000-299 999 used as reference
Odds ratios are approximately equal to relative risks.

Table 9b (girls). Odds ratios for SCQ high score by paternal income.

Adjustment factors	B	S.E.	Wald	*p*	Exp(B)	95% C.I. for Exp(B)
No income	-16,18	3855	0,000	0,997	0,000	-
Below 150 000	0,87	0,39	5,03	0,025	2,39	1,12-5,10
150 000-199 999	-0,57	0,74	0,58	0,445	0,57	0,13-2,43
200 000-299 999	-	-	-	-	1,00	-
300 000-399 999	0,31	0,28	1,16	0,281	1,36	0,78-2,37
400 000-499 999	-0,08	0,40	0,40	0,840	0,92	0,42-2,02
Above 500 000	0,01	0,40	0,001	0,982	1,01	0,46-2,22
Unknown	1,62	0,57	8,15	0,004	5,05	1,66-15,33
Mother >= 35 years	-0,46	0,35	1,67	0,196	0,63	0,32-1,27
Father >= 40 years	0,53	0,35	2,23	0,135	1,69	0,85-3,38
Mother not living with father	0,37	0,42	0,79	0,376	1,44	0,64-3,24

200 000-299 999 used as reference
Odds ratios are approximately equal to relative risks.

In **Table 10** we look at how the number of children with SCQ-33 >=12 vary with the mother's age. In the boys' group the numbers in the two lowest categories are larger than the expected counts (5 vs. 1,7 and 27 vs. 21,4), indicating that younger mothers have an increased risk of having a child with autistic traits. Among the girls it is more difficult to recognize a clear trend.

Table 10. SCQ high score by maternal age.

Mother's age	Boys SCQ-33 >=12	Boys Total	Boys %>=12	Girls SCQ-33 >=12	Girls Total	Girls %>=12
Below 20	5 (1,7)	103	4,9	2 (0,7)	98	2,0
20-24	27 (21,4)	1336	2,0	13 (8,4)	1219	1,1
25-29	80 (75,4)	4706	1,7	31 (31,3)	4543	0,7
30-34	81 (84,7)	5283	1,5	36 (35,8)	5193	0,7
35-39	27 (31,6)	1969	1,4	9 (13,5)	1955	0,5
40 and above	3 (3,8)	237	1,3	2 (1,7)	244	0,8
Missing	0 (4,5)	282	0,0	0 (1,7)	254	0,0
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the age groups.
The %>=12 is the share of children with SCQ-33>=12 within each age group.
"Missing" represents subjects who did not obtain valid SCQ-33-scores.

When looking at father's age in **Table 11**, we see quite another picture. Among the boys, the share of children with SCQ-33 >=12 seems to increase in the two highest age categories, compared to the mean. The percentages are high in the lowest categories as well, yet this could partly be due to a small number of young fathers, especially in the <20-group (n=37).

Table 11. SCQ high score by paternal age.

Father's age	Boys SCQ-33 >=12	Boys Total	Boys %>=12	Girls SCQ-33 >=12	Girls Total	Girls %>=12
Below 20	1 (0,6)	37	2,7	0 (0,2)	27	0,0
20-24	12 (8,8)	550	2,2	5 (3,6)	528	0,9
25-29	54 (51,1)	3186	1,7	23 (20,4)	2967	0,8
30-34	83 (85,7)	5346	1,6	36 (36,4)	5293	0,7
35-39	42 (50,2)	3131	1,3	15 (21,0)	3045	0,5
40-44	22 (15,2)	950	2,3	10 (6,4)	924	1,1
45 and above	7 (5,5)	343	2,0	3 (2,5)	370	0,8
Missing	2 (6,0)	373	0,5	1 (2,4)	352	0,3
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the age groups.
The %>=12 is the share of children with SCQ-33>=12 within each age group.
"Missing" represents subjects who did not obtain valid SCQ-33-scores.

In the last table concerning SCQ-33 with 12 as cutoff, we investigate how the mother's marital status, as given in the 36 months questionnaire, influences the number of children with SCQ-33 >=12, see **Table 12**. In the boys section, the single group has a markedly increased risk of having a child scoring >=12, compared to the risk in the married and cohabitant groups. For the other groups the number of participants is too small. Also in the girls' section, the number of children scoring >=12 is too small for any conclusions to be drawn.

Table 12. SCQ high score by maternal marital status.

Mother's marital status	Boys SCQ-33 >=12	Boys Total	Boys %>=12	Girls SCQ-33 >=12	Girls Total	Girls %>=12
Married	118 (132,7)	8284	1,4	46 (56,3)	8175	0,6
Cohabitant	70 (64,5)	4022	1,7	29 (25,9)	3764	0,8
Single	14 (6,7)	419	3,3	6 (2,7)	391	1,5
Divorced/separated	5 (3,0)	188	2,7	3 (1,4)	205	1,5
Widow	0 (0,5)	30	0,0	0 (0,1)	21	0,0
Other	5 (1,4)	88	5,7	1 (0,6)	84	1,2
Missing	11 (14,0)	876	1,3	8 (5,9)	860	0,9
Total	**223 (223)**	**13916**	**1,6**	**93 (93)**	**13506**	**0,7**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of SCQ >=12 across the marital status groups.
The %>=12 is the share of children with SCQ-33>=12 within each marital status group.
"Missing" represents subjects who did not provide an answer to the marital status question, or did not obtain valid SCQ-33-scores.

ASD-ST as outcome variable

Starting out by looking at how the mother's educational level and the number of children given ASD-ST diagnoses covariate (**Table 13**), we see no apparent trends in the girls' section due to the very low number of diagnosed children. Among the boys, there is a significant difference between the vocational high school group and the 3-4 year university/college group (p=0,006). Regarding the other educational groups, it is difficult to recognize any trends. Because of the low numbers of diagnosed children, the logistic regression tables provide little information and will not be presented here.

Table 13. ASD-ST diagnoses by maternal education.

Mother's educational level	Boys ASD-ST	Boys Total	Boys %ASD-ST	Girls ASD-ST	Girls Total	Girls %ASD-ST
9-year secondary school	2 (1,0)	320	0,6	1 (0,3)	287	0,3
1-2 year high school	2 (2,1)	645	0,3	1 (0,8)	654	0,2
Vocational high school	11 (5,9)	1813	0,6	4 (2,0)	1719	0,2
3-year high school	4 (6,8)	2097	0,2	2 (2,4)	2027	0,1
3-4-year university/college	11 (18,5)	5721	0,2	6 (6,5)	5519	0,1
University/college >4 years	10 (8,0)	2488	0,4	1 (3,0)	2546	0,0
Missing	5 (2,7)	832	0,6	1 (0,9)	754	0,1
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the educational groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each educational group.
"Missing" represents subjects who did not provide an answer to the educational question.

The next table (**Table 14**) shows no association between the father's education and the child's risk of being diagnosed with an ASD-ST.

Table 14. ASD-ST diagnoses by paternal education.

	Boys			Girls		
Father's educational level	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
9-year secondary school	3 (2,0)	624	0,5	0 (0,8)	654	0,0
1-2 year high school	3 (2,7)	846	0,4	2 (1,0)	808	0,2
Vocational high school	11 (11,6)	3575	0,3	4 (4,1)	3475	0,1
3-year high school	5 (5,0)	1534	0,3	3 (1,8)	1492	0,2
3-4-year university/college	12 (11,2)	3462	0,3	4 (3,9)	3326	0,1
University/college >4 years	8 (8,0)	2482	0,3	2 (2,9)	2441	0,1
Missing	3 (4,5)	1393	0,2	1 (1,6)	1310	0,1
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the educational groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each educational group.
"Missing" represents subjects who did not provide an answer to the educational question.

We consider the mother's income and the risk of obtaining an ASD-ST diagnosis in **Table 15**, and conclude that no clear trend can be seen. The same applies to **Table 16**, which concerns the father's income.

Table 15. ASD-ST diagnoses by maternal income.

	Boys			Girls		
Mother's income	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
No income	1 (1,0)	301	0,3	0 (0,3)	292	0,0
Below 150 000	12 (7,4)	2294	0,5	3 (2,6)	2157	0,1
150 000-199 999	7 (5,8)	1794	0,4	1 (1,9)	1643	0,1
200 000-299 999	14 (17,6)	5442	0,3	4 (6,3)	5301	0,1
300 000-399 999	6 (7,8)	2420	0,2	4 (2,9)	2478	0,2
400 000-499 999	1 (2,1)	664	0,2	1 (0,8)	645	0,2
Above 500 000	3 (1,2)	368	0,8	2 (0,5)	382	0,5
Missing	1 (2,0)	633	0,2	1 (0,7)	608	0,2
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the income groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each income group.
"Missing" represents subjects who did not provide an answer to the income question.

Table 16. ASD-ST diagnoses by paternal income.

	Boys			Girls		
Father's income	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
No income	0 (0,4)	116	0,0	0 (0,1)	110	0,0
Below 150 000	5 (2,4)	744	0,7	0 (0,8)	714	0,0
150 000-199 999	0 (2,0)	615	0,0	0 (0,7)	587	0,0
200 000-299 999	11 (12,2)	3776	0,3	5 (4,3)	3664	0,1
300 000-399 999	13 (13,4)	4149	0,3	7 (4,8)	4053	0,2
400 000-499 999	5 (5,9)	1831	0,3	0 (2,1)	1748	0,0
Above 500 000	7 (5,2)	1595	0,4	2 (1,9)	1586	0,1
Unknown	0 (0,5)	157	0,0	0 (0,2)	130	0,0
Missing	4 (3,0)	933	0,4	2 (1,1)	914	0,2
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the income groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each income group.
"Missing" represents subjects who did not provide an answer to the income question.

Tables 17 and 18 consider mother's and father's ages respectively. No tendencies are seen in either table.

Table 17. ASD-ST diagnoses by maternal age.

	Boys			Girls		
Mother's age	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
Below 20	0 (0,3)	106	0,0	0 (0,1)	102	0,0
20-24	4 (4,4)	1363	0,3	3 (1,5)	1261	1,5
25-29	18 (15,5)	4802	0,4	4 (5,5)	4615	0,1
30-34	14 (17,4)	5386	0,3	8 (6,3)	5284	0,2
35-39	9 (6,5)	2014	0,4	1 (2,4)	1996	0,1
40 and above	0 (0,8)	245	0,0	0 (0,3)	248	0,0
Missing	0 (0,0)	0	0,0	0 (0,0)	0	0,0
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the age groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each age group.

Table 18. ASD-ST diagnoses by paternal age.

	Boys			Girls		
Father's age	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
Below 20	0 (0,1)	39	0,0	0 (0,0)	28	0,0
20-24	1 (1,8)	560	0,2	1 (0,7)	549	0,2
25-29	13 (10,5)	3241	0,4	4 (3,6)	3030	0,1
30-34	13 (17,7)	5459	0,2	8 (6,4)	5379	0,1
35-39	11 (10,3)	3199	0,3	3 (3,7)	3099	0,1
40-44	6 (3,1)	971	0,6	0 (1,1)	946	0,0
45 and above	1 (1,1)	356	0,3	0 (0,4)	376	0,0
Missing	0 (0,3)	91	0,0	0 (0,1)	99	0,0
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the age groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each age group.
"Missing" represents subjects where father's age is not provided.

The last table considering ASD-ST (**Table 19**), concerns how mother's marital status and ASD-ST are interrelated. The numbers of diagnoses in the groups other than "married" and "cohabitant" are too small to detect any tendencies.

Table 19. ASD-ST diagnoses by maternal marital status.

	Boys			Girls		
Mother's marital status	ASD-ST	Total	%ASD-ST	ASD-ST	Total	%ASD-ST
Married	22 (27,3)	8435	0,3	11 (9,8)	8312	0,1
Cohabitant	15 (13,3)	4119	0,4	2 (4,6)	3849	0,1
Single	1 (1,4)	430	0,2	0 (0,5)	399	0,0
Divorced/separated	1 (0,6)	189	0,5	0 (0,2)	207	0,0
Widow	0 (0,1)	30	0,0	0 (0,0)	21	0,0
Other	2 (0,3)	90	2,2	0 (0,1)	86	0,0
Missing	4 (2,0)	613	0,6	3 (0,7)	632	0,5
Total	**45 (45)**	**13916**	**0,3**	**16 (16)**	**13506**	**0,1**

The numbers in ( ) indicate expected count, i.e. the number of individuals expected to be found if there was an equal percentage of ASD-ST diagnoses across the marital status groups.
The %ASD-ST is the share of children with an ASD-ST diagnosis within each marital status group.
"Missing" represents subjects who did not provide an answer to the marital status question.

<u>ASD as outcome variable</u>

The same analyses as for ASD-ST, were also performed using ASD as the outcome variable. As the ASD cases were even fewer (41 compared to 61), with each

ASD case also being an ASD-ST case, the results overlap to a large extent. Given that it was difficult to discover tendencies in the ASD-ST material, apparent trends were non-existent in the ASD material. The tables are therefore not listed in this report.

Investigation of possible selection bias

First we investigate if there is any SES bias, comparing the responders and the non-responders to the 36 months questionnaire, starting with maternal and paternal educational level (**Tables 20 and 21**). Concerning maternal education, there is a clear and significant ($p<0,001$) tendency towards lower response with lower education. The percentages range from 43,4 in the 9-year secondary school group and 50,1 in the 1-2 year high school group, to about 67 in the university/college groups. The same tendency is seen for paternal education, although less pronounced.

Table 20. Response to 36 months questionnaire by maternal education.

Mother's educational level	Responders	Total	%response
9-year secondary school	468	1078	43,4
1-2 year high school	1017	2030	50,1
Vocational high school	2727	4734	57,6
3-year high school	3205	5318	60,3
3-4-year university/college	8478	12608	67,2
University/college >4 years	3658	5451	67,1
Missing	1225	2591	47,3
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
"Missing" represents subjects who did not provide an answer to the educational question.

Table 21. Response to 36 months questionnaire by paternal education.

Father's educational level	Responders	Total	%response
9-year secondary school	998	1832	54,5
1-2 year high school	1267	2184	58,0
Vocational high school	5415	8762	61,8
3-year high school	2322	3828	60,7
3-4-year university/college	5084	7661	66,4
University/college >4 years	3612	5536	65,2
Missing	2080	4007	51,1
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
"Missing" represents subjects who did not provide an answer to the educational question.

Similar trends are seen for maternal and paternal income (**Tables 22 and 23**), with lower income being related to a lower response percentage. The trend is more obvious for mother's income than for father's income.

Table 22. Response to 36 months questionnaire by maternal income.

Mother's income	Responders	Total	%response
No income	432	900	48,0
Below 150 000	3468	5917	58,6
150 000-199 999	2701	4482	60,3
200 000-299 999	8243	12717	64,8
300 000-399 999	3475	5259	66,1
400 000-499 999	938	1464	64,1
Above 500 000	530	847	62,6
Missing	991	2224	44,6
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
"Missing" represents subjects who did not provide an answer to the income question.

Table 23. Response to 36 months questionnaire by paternal income.

Father's income	Responders	Total	%response
No income	169	300	56,3
Below 150 000	1113	1871	59,5
150 000-199 999	952	1601	59,5
200 000-299 999	5822	9208	63,2
300 000-399 999	6146	9693	63,4
400 000-499 999	2605	4084	63,8
Above 500 000	2307	3603	64,0
Unknown	225	425	52,9
Missing	1439	3025	47,6
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
"Missing" represents subjects who did not provide an answer to the income question.

Next we move on to look at how maternal and paternal age influence the response to the 36 months questionnaire (**Tables 24 and 25**). For mother's age we see a significantly (p<0,001) lower response percentage in the lowest two age categories, 42,0 and 54,7, compared to the mean 61,5. There is, unsurprisingly, a similar tendency with father's age.

Table 24. Response to 36 months questionnaire by maternal age.

Mother's age	Responders	Total	%response
Below 20	160	381	42,0
20-24	2045	3741	54,7
25-29	7200	11501	62,6
30-34	8025	12832	62,5
35-39	2969	4758	62,4
40 and above	379	597	63,5
Missing	0	0	0,0
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.

Table 25. Response to 36 months questionnaire by paternal age.

Father's age	Responders	Total	%response
Below 20	51	112	45,5
20-24	878	1677	52,4
25-29	4844	7887	61,4
30-34	8229	13098	62,8
35-39	4744	7707	61,6
40-44	1428	2296	62,2
45 and above	553	888	62,3
Missing	51	145	35,2
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
"Missing" represents subjects where father's age is not provided..

In **Table 26**, we look at how marital status, as obtained in the first questionnaire, during pregnancy, relates to the response percentage to the 36 months questionnaire. Of course, we could not use the marital status obtained in the 36 months questionnaire for this purpose, as marital status among the non-responders is only known from the first questionnaire. We see that the response rate is markedly higher among the mothers who were living with the father early in pregnancy.

Table 26. Response to 36 months questionnaire by maternal marital status.

Mother's marital status	Responders	Total	%response
Married	10599	16505	64,2
Cohabitant	9267	15178	61,1
Single	354	693	51,1
Divorced/separated	49	105	46,7
Other	173	308	56,2
Missing	305	968	31,5
Total	**20778**	**33810**	**61,5**

The %response is the share of parents to children born before 2005 who have responded to the 36 months questionnaire.
The widow group is included in "other" due to small numbers.
"Missing" represents subjects who did not provide an answer to the marital status question.

Tables 27 and 28 describe how attendance at clinical examination among screen positives depends on maternal educational level and income, respectively. In the first table there is a slight tendency towards a lower attendance among the lower educated mothers. The only number not fitting in with such a tendency is the 63,2% attendance in the vocational high school group. The table concerning maternal income shows no tendencies at all. We have chosen not to present the tables for father's education, income and age as we could see no trends emerging in either table. For the same reason, we will neither present the table regarding mother's age.

Table 27. Attendance at clinical examination among screen positives.

Mother's educational level	Attendants	Total	%response
9-year secondary school	5	14	35,7
1-2 year high school	9	26	34,6
Vocational high school	24	38	63,2
3-year high school	18	44	40,9
3-4-year university/college	46	86	53,5
University/college >4 years	24	47	51,1
Missing	6	20	30,0
Total	**132**	**275**	**48,0**

The %response is the share of parents to children born before 2005 who have attended clinical examination.
"Missing" represents subjects who did not provide an answer to the educational question.

Table 28. Attendance at clinical examination among screen positives.

Mother's income	Attendants	Total	%response
No income	2	9	22,2
Below 150 000	27	52	51,9
150 000-199 999	10	29	34,5
200 000-299 999	53	93	57,0
300 000-399 999	23	49	46,9
400 000-499 999	8	16	50,0
Above 500 000	6	10	60,0
Missing	3	17	17,6
Total	**132**	**275**	**48,0**

The %response is the share of parents to children born before 2005 who have attended clinical examination.
"Missing" represents subjects who did not provide an answer to the income question.

Looking at marital status in **Table 29**, we see that there is a slight trend towards a higher attendance percentage in the married and cohabitant groups compared to the single and divorced/separated groups, although the latter groups suffer from a low total count.

Table 29. Attendance at clinical examination among screen positives.

Mother's marital status	Attendants	Total	%response
Married	72	159	45,3
Cohabitant	36	71	50,7
Single	4	14	28,6
Divorced/separated	1	4	25,0
Other	2	2	100,0
Missing	17	25	68,0
Total	**132**	**275**	**48,0**

The %response is the share of parents to children born before 2005 who have attended clinical examination.
"Missing" represents subjects who did not provide an answer to the marital status question.

Last we investigate differences in mean SCQ-33 scores between those attending and those not attending the clinical examination, comparing 2 groups: Those being screen positive, and those being screen positive AND at the same time having SCQ-33 scores >=12, see **Tables 30 and 31.** Starting with **Table 30**, we see that for boys the mean score is 1,49 higher for those attending than for the non-attending. Using independent sample t-test, we find that this difference is statistically significant at p=0,031. For girls there is a mean difference of 0,93, however not statistically significant. **Table 31** shows a smaller difference for boys of 1,05, and the difference is not significant. For girls the difference is quite large, 3,26, but due to small samples it is not significant (p=0,058).

Table 30. Difference in mean SCQ-33 score between attendants and non-attendants among screen positive children.

	Boys			Girls		
Attending	No.	Mean	Std. deviation	No.	Mean	Std. deviation
Yes	93	10,32	4,86	34	9,76	6,55
No	89	8,83	4,37	48	8,83	4,43

Table 31. Difference in mean SCQ-33 score between attendants and non-attendants among screen positive children with SCQ-33 >=12.

	Boys			Girls		
Attending	No.	Mean	Std. deviation	No.	Mean	Std. deviation
Yes	36	15,17	3,52	11	17,64	4,72
No	25	14,12	2,51	13	14,38	2,50

DISCUSSION

In this study we have investigated whether there is an association between parental socioeconomic status and the development of autistic traits among children screened 36 months after birth within the Norwegian Mother and Child Cohort Study. Our exposure variables have been parental education, income, age and marital status. Our outcome variables have been SCQ-33 score (obtained 36 months after birth) using the cutoff of 12, and clinical diagnoses of Autism Spectrum Disorders (ASDs) and ASDs including sub-threshold diagnoses. To the best of our knowledge, MoBa is the first study to use SCQ as a screening tool on a general population, and in a large sample. This implicates that direct comparison of our results to previous findings cannot easily be carried out, as other researchers have focused either on autism alone or the ASDs combined.

Main results

The clearest association between SES and autistic traits appears when analysing how educational level correlates with SCQ high score. For maternal education, the unadjusted analyses show a fivefold risk in the boys' section of having an SCQ score >=12 in the 9-year secondary school group compared to the highest educational category. For girls the tendency is even clearer, although with a lower number of SCQ high scorers. For paternal education the trend was similar. Adjusted analyses confirm these findings. Regarding educational level and ASD-ST diagnoses, there are no clear trends, although for mother's education in the boys' section, we observed a significantly increased risk of obtaining a diagnosis when comparing the vocational high school group to the 3-4-year college/university group. As previously mentioned, the number of children obtaining an ASD diagnosis is too small for any trends to be discovered.

The analyses of a possible association between maternal income and SCQ high score also show significant tendencies towards a higher number of children with SCQ>=12 in the income categories considered to be low SES groups. Basically this trend is the same as for maternal education, only less pronounced. For paternal income it is interesting to notice that while for boys the trend is quite clear with a preponderance of SCQ high scorers in the low income groups, for girls there is no trend. As mentioned in the results section, there are no trends to be seen in neither the ASD-ST analyses nor the ASD analyses.

In previous studies designed to investigate a possible relationship between SES factors and the development of autistic traits, the most important exposure variables have been parental education and income. At the same time, these studies have invariably been looking at clinical diagnoses of Autism Spectrum Disorders as outcome variables. As is evident from our Introduction, the question of SES and autism has long been debated, and as we see it, the issue remains unsolved. That said, an important and recent large Danish study (Larsson et al., 2005) was not able to demonstrate a clear relation between SES and autism in their adjusted analyses. Bearing in mind that we have used a different outcome variable in our main analyses, namely SCQ high score, we can conclude that our results stand in contrast to most studies performed to date, inasmuch as we find an increased risk of development of autistic traits in families with low SES. As pointed out earlier, this trend almost disappears when we look at clinical diagnoses.

Croen (Croen et al., 2007) and Kolevzon (Kolevzon et al., 2007) have shown that advanced maternal age is associated with an increased risk of having children with an ASD. In our material there is no correlation between maternal age and ASD-ST or ASD, possibly due to small numbers. On the other hand our analyses regarding maternal age and SCQ high score reveal a significantly higher proportion of high scorers in the two lowest age categories.

Reichenberg (Reichenberg et al., 2006) and Croen (Croen et al., 2007) have demonstrated an association between advanced paternal age and an increased risk of having children with an ASD. Our results regarding paternal age and SCQ high score seem to support this view, although it is noticeable that low paternal age is also associated with an increased risk of a SCQ high score. Obviously, as young mothers tend to have young partners, this latter point could easily be influenced by the increased risk among young mothers indicated in this study.

Regarding marital status and the number of SCQ high scorers, it seems to be more likely to have a child with high SCQ score if you are single and/or divorced. We can find no previous studies performed on this issue.

<u>Strengths and weaknesses</u>

Starting with the strengths of our study; we have a large number of participants in the MoBa study due to the nationwide recruitment program, and so a large number of children are screened for the presence of autistic traits. Using a cohort design is normally thought of as a great advantage in epidemiological studies investigating etiological factors in disease, mostly because prospective data collection diminishes the risk of recall bias. For our purpose this is of minor importance, as information concerning the exposure variables (education, income, age and marital status) could just as well have been obtained at the time of diagnosis. At any rate, the longitudinal design means that the population under study is well defined and that participants are recruited irrespective of their SES. An obvious strength is that the diagnostic evaluation for the screen positive population is thorough and free of charge. If the clinical evaluation following the screening process had been expensive, the attendance would have constituted a serious source of selection bias. Performing the main bulk of our analyses using SCQ score >=12 as the outcome variable has the advantage of yielding a high number of children with autistic traits, adding statistical strength.

One point which negatively affects the ASD-ST analyses but not the SCQ analyses, is the limited number of clinical diagnoses given thus far. 61 ASD-ST cases are included in our study, but more would be needed to be able to draw conclusions regarding a possible connection to SES. As pointed out earlier, the desired number of participants are now included in the ABC study, and in a couple of years time the number of clinical diagnoses will have risen considerably. This will hopefully provide clearer results regarding this issue in the future.

As is evident from the results of our investigation of a possible selection bias, the response rate to the 36 months questionnaire is markedly lower for the low SES groups, measured by parental educational level and income. This trend was most pronounced in the maternal education analysis, as was the trends in our main analyses. It is hard to say whether this difference could have any influence on our main results, as we have no information concerning the development of autistic traits (SCQ-score) among those not responding. Low parental age and the mother not living with father also increases the risk of the mother not returning the 36 months questionnaire, but again it is difficult to predict how this could influence the results.

As we see it, the results are more likely to be adversely affected by a low attendance rate at clinical examination among the screen positives. As we saw in the Results section, there is, if anything, a slight trend towards a lower attendance rate in the lower SES groups. Of course this does not affect our main results concerning SCQ high score in any way, but it could lead to a falsely low number of ASD-ST diagnoses in the lower SES groups. In this respect, the analyses of mean SCQ scores in the attendant and non-attendant groups are interesting, and show that in all categories, the attendants do have higher mean SCQ scores than do the non-attendants. This signifies that the children who meet for diagnostic evaluation are actually more likely to suffer from an ASD, meaning that the aforementioned potential problem of a falsely low number of diagnoses in the low SES groups could in the end turn out not to be that serious.

Then there is the question of how well the SCQ works as a screening tool for autism used on a general population. As previously pointed out, the validation studies to this date have used clinical samples. It is outside the scope of this study to evaluate how well the SCQ has been able to correlate with the clinical diagnoses given at the diagnostic evaluation. For our purpose we reasoned that the SCQ would anyhow provide reliable information about the presence of *autistic traits*, as the form is very much built around the symptomatology of the Autistic Spectrum Disorders. As it is, our purpose of investigation was precisely to examine the connection between *autistic traits* and SES.

Conclusion

By using SCQ-33 with a cutoff of >=12 as a measure of autistic traits among children screened 36 months after birth, we are able to conclude that low socioeconomic status (SES), measured by parental education and income, is associated with an increased risk of having a child with autistic traits. This trend was not significant when using clinical diagnoses as outcome variable.

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